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November 1993
NSRP 0408

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1993 Ship Production Symposium

Paper No. 7: Fundamentals of Arc Stud Welding: An Interactive Multimedia Lesson for Shipyard Training

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
NOV 1993	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The National Shipbuilding Research Program, 1993 Ship Production Symposium Paper No. 7: Fundamentals of Arc Stud Welding: An Interactive Multimedia Lesson for Shipyard Training	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tower Bldg 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**11**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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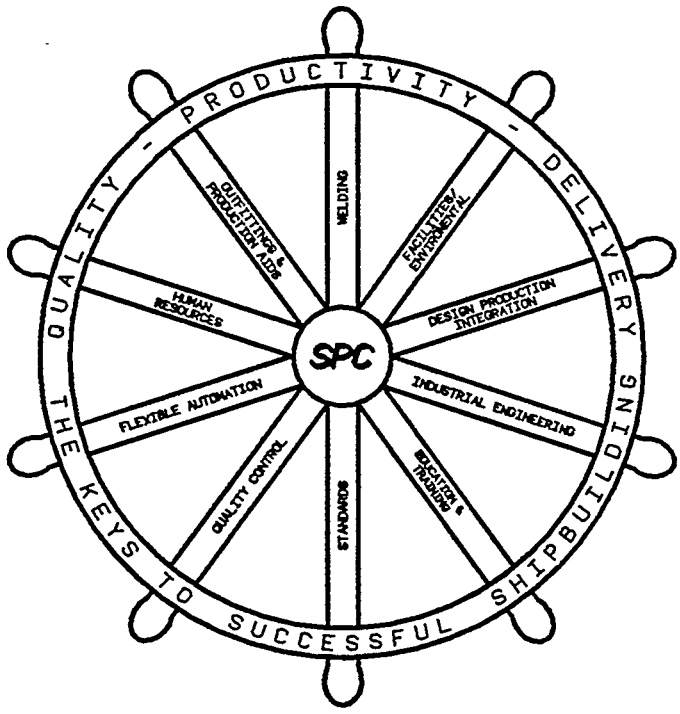

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Williamsburg Virginia, November 1-4, 1993

The National Shipbuilding Research Program
1993 Ship Production Symposium
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Fundamentals of Arc Stud Welding: An Interactive Multimedia Lesson for Shipyard Training

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ABSTRACT

SP-9's 1991 report, "Recommendations on the Use of Interactive Instruction for Training Shipyard Trade Skills," indicates that although very few American shipyards have used it or are familiar with it, interactive multimedia has great potential as a low-cost, effective method for the training of skilled trade tasks. These findings led SP-9 to develop an interactive lesson that demonstrates how interactive multimedia can be integrated into shipyard training programs to reduce training costs, increase productivity, promote quality awareness, and improve worker competence.

The demonstration combines computer graphics, animation, still and motion video, sound, and touchscreen interaction to demonstrate the broad spectrum of the interactive multimedia technology. This paper describes the project as an example of how shipyard training departments can develop their own interactive multimedia courseware by determining appropriate applications of the technology selecting the most suitable hardware and authoring system for delivering the instruction researching, planning and designing the lessons; and shooting the video, authoring the courseware, and integrating them into an effective interactive multimedia course.

INTERACTIVE INSTRUCTION

Interactive multimedia is the result of technology's ability to bring together, in a low-cost computer environment, new forms of visual and auditory stimuli, and allow human operators to interact with them in ways never before possible. Faster yet smaller processors, large capacity desk-top storage, life-like color motion and high-resolution display capabilities, and a variety of new interface technologies produce highly effective exchanges of information between the media and its user. Interactive multimedia has become the platform from which ambitious applications of instructional technology are being launched worldwide.

"Interactive instruction," as the name implies, uses interactive multimedia for education and training. It requires the trainee to become an integral part of the overall educational process. Interactive instruction links an audio/visual presentation to a microcomputer through the use of computer software specifically designed to react to each trainee's individual needs. It establishes a personal relationship between the trainee and the subject matter to& learned. The combination of sight, sound, personal interaction, and computer control provides a highly effective learning environment.

COMPONENTS OF INTERACTIVE INSTRUCTION

The components of interactive instruction are as fluid as the computer industry that produces them. Their functions, however, remain consistent: to stimulate, to evaluate, and to communicate. Technological advancements such as digital video (DVI) and compact disc (CD-I and CD-ROM) do much to enhance the learning environment, and are being rapidly accepted in the instruction role. Interactive videodisc (ND), however, continues as the most popular media for interactive motion video, and it is the platform that is used in this project.

The IVD platform consists of the following six essential components, although others can be added to expand this particular multimedia technology capability.

1. A desk-top personal computer (PC) that initiates all the instructional features, processes and evaluates trainee responses, and provides lesson management.
2. A color monitor for the presentation of visual information from the computer and video player.
3. Interaction devices, such as a touchscreen that signals the computer when and where the screen is touched, and a keyboard for answering questions with numbers or text.

4. A graphics its overlay board with Super VGA capabilities that permtis the combined display of motion video and computer graphics on the monitor.
5. A laser disc player that retrieves video imagery and audio information from a 12-inch optical disc. The retrieved information is controlled by the computer. Videodiscs, unlike video tape, provide the ability to access any portion of a video program instantly. This allows the computer to "branch" to other video segments, skip ahead, or repeat.
6. IVD courseware that manages and administers the training program, and a videodisc that contains the video portion of the lesson.

BENEFITS OF INTERACTIVE INSTRUCTION

Interactive instruction has acquired, and continues to acquire accolades for its achievements in cost-effective training. Industry, government, and the academic community attribute this to the way the multimedia is designed and, equally important, to the way it is applied. Studies (1 and 2) compiled over the past two decades have found that computer-aided instruction significantly reduces training time. This is due to the instructional method of "self-pacing" that directs the most efficient path of learning, the use of auditory cues and narration to reinforce text and pictures, the immediacy of feedback to augment trainee actions, and the computer's "capacity" to adapt to personalized styles to maximize learning efficiency.

The cost of interactive instruction lies mostly in its initial production, not its distribution or use. For this reason, cost-per-trainee is reduced as more trainees use the program. Also important, interactive instruction does not have "bad" days, or tire toward the end of a session. Instruction is delivered consistently and reliably. With interactive instruction, trainees are free to ask questions and explore ideas that might otherwise cause embarrassment. Interactive instruction encourages trainees to persevere and review materials until real mastery is achieved. Unlike traditional training, interactive instruction does not present new material until current material is mastered. This ensures that trainees have strong foundations for continued learning.

Trainees can explore potentially hazardous subjects or dangerous activities without risk to equipment or themselves. In addition, one-to-one interactive instruction focuses the trainee's attention, thereby reducing distraction or disruption. Individual involvement is highly motivating to the trainee and instills a sense of responsibility. The portability of delivery systems can establish a training environment in locations where trainee populations would not otherwise support full-time instructors or where qualified instructors are unavailable. Interactive instruction also makes "any time" training a reality. This is extremely important in a production environment that operates round-the-clock

Trainees who use interactive instruction take greater control and responsibility for their own learning process. As they become more accomplished learners, they become fully active participants in the learning process, not just passive recipients of instruction. As a result, the training "sticks."

Interactive instruction is particularly effective in the shipyard environment where worker proficiency must be proven and documented, and where trainees vary in experience, learning ability, reading ability, or language. The low-cost and portability of the delivery system is a significant benefit where there are many trainees distributed over time or in different locations. Also, the use of multimedia and computer-based training, and the operation of PCs are familiar to most shipyard training personnel.

THE SP-9 PROJECT

The project described in this paper is being sponsored by the Education and Training Panel, SP-9, to demonstrate the benefits of interactive instruction to shipyard management and training department personnel. The project has resulted in an interactive lesson on the "Fundamentals of Arc Stud Welding" to be used by shipyards both to evaluate the training-effectiveness of interactive instruction, and to determine the ease with which interactive courseware can be developed by the shipyards themselves.

Goals of the Project

The specific goals of the project are

1. To demonstrate to shipyard training departments and personnel the use and benefits of interactive instruction for training shipyard skilled trades,
2. To demonstrate how interactive instruction can be used for both tutorial and simulation lessons,
3. To demonstrate to shipyard training departments and personnel the ease and low cost with which interactive instruction courseware can be developed and produced in-house,
4. To provide an interactive lesson on the fundamentals of arc stud welding, and

5. To provide the Shipyard Instructional Design Center and other shipyard training departments with experience in the development of interactive instructional courseware.

Methodology

The Fundamentals of Arc Stud Welding interactive lesson was developed jointly by Ship Analytics, Inc. and NAVSEA'S Shipyard Instructional Design Center (SIDC), Norfolk Naval Shipyard. The lesson was produced using a popular, commercially-available authoring system. This authoring system, and the hardware used to support it, was selected after a thorough review of the various types and capabilities of authoring systems, and the different multimedia technologies associated with interactive instruction. Most favorable for the selected authoring system was its ease of operation, capacity for expansion, relatively low cost, and overall popularity among interactive courseware developers. There are may other authoring systems available that would have been equally acceptable, and many additional ones continue to appear on the market.

The hardware used for the SP-9 demonstration lesson consists of a U.S. manufactured IBM-compatible 80486 computer operating at 25MHz. Computer speed is important when re-drawing interactive multimedia displays. The computer is equipped with Super VGA, a surface acoustic wave touchscreen color monitor, a graphics overlay board for displaying graphics on top of video pictures, and a laser videodisc player. Similar hardware for interactive videodisc systems is available on the commercial market for approximately $7,000. Similar-capability authoring systems are available on the commercial market for less than $2,000. This means that a complete interactive instruction system can be purchased for under $10,000, and can be used in shipyards to develop and teach hundreds of interactive lessons.

The Development Process

Development of the SP-9 interactive lesson followed the traditional process illustrated in Figure 1. This process required the formal publication of "objectives," a "flow diagram," "storyboards" complete with screen text, narration, video and graphics, and a video shot list to guide the video production.

WHY ARC STUD WELDING?

A major objective of the SP-9 lesson is to demonstrate that interactive multimedia is extremely effective at providing both "tutorial" and "simulation" instruction. Since cognitive skills (those requiring mental processing of facts) are best taught through the tutorial process, and stimulus-response (or "trial and error") skills are best taught through simulation; it was decided to select a complex shipyard trade task that would benefit from both types of learning. Portable electric arc stud welding was determined to be such a task.

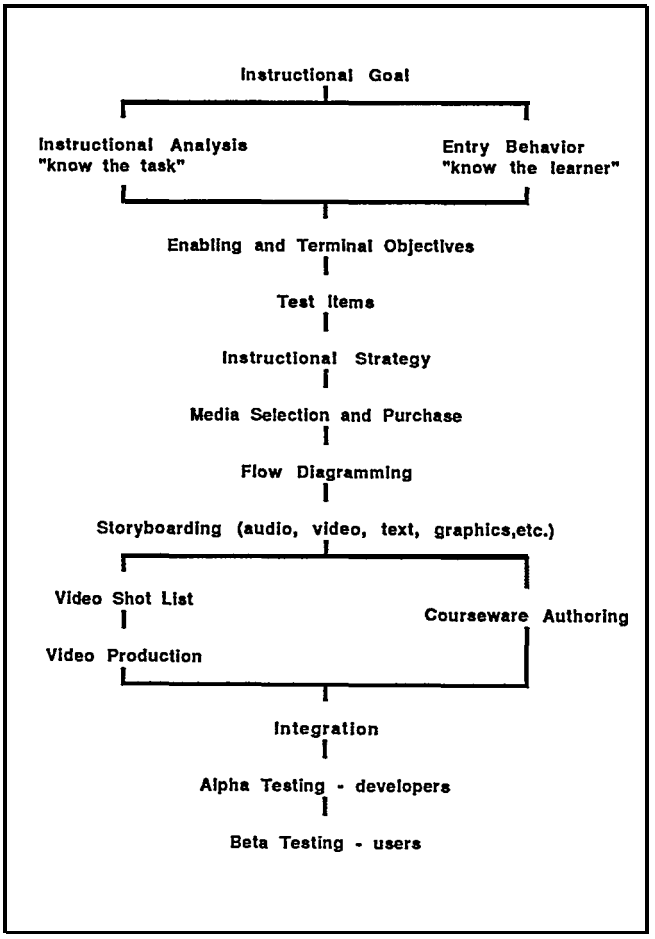

Figure 1 The Interactive Courseware Development Process

Tutorial

Interactive instruction as a tutorial presents the material to be learned in a methodical, progressive manner such that the information imparted to the trainee

is easily understood, easy to remember, and easy to apply. The subject material is usually one that requires competence in recognition and interpretation, knowledge of procedures and processes, ability to analyze and make decisions, and the ability to communicate. Such training is traditionally taught by lecture, reading, and audio/video tape. Interactive instruction, however, adds the elements of motivation and self-pacing through sensory stimulus, physical interaction, continuous testing, feedback, and branching.

Simulation

The other effective use of interactive instruction is practicing skills and rehearsing complex procedures through simulation. Training a skill such as arc stud welding, that requires extensive trial and error coordination and the rehearsal of procedures for gun adjustment and inspection of welds, is an excellent application of simulation. For this application, pictures of actual equipment are shown. The trainee can touch the picture to simulate handling or adjusting equipment, and the picture changes in response to the action. The trainee is thereby guided through both set-up and operating tasks, and can experience the consequences of his or her actions. The trainee can also practice procedures over and over before being tested.

Of particular importance is the cost savings realized by having the trainee learn procedures and practice skills without using actual equipment. Interactive instruction eliminates the need to take equipment out of service for training purposes, and significantly reduces the risk of injury to personnel or damage to equipment.

THE LESSON

The interactive lesson uses text, graphics, animation, photographs, still and motion video, and sound to stimulate learning. It uses a touchscreen to accept trainee responses, and it illustrates self-pacing through a variety of different types of remediation and feedback loops. Trainees are automatically screened with a pre-test just as they would be in traditional training, and their performance is verified and documented at the end of each lesson. Answer analysis and student management, routinely conducted during training, are also performed by the system.

One additional objective of the lesson is to illustrate different presentation and feedback techniques that are available through interactive instruction. The lesson carefully balances this objective with the requirement of a good interactive lesson which is to maintain consistency throughout.

Lesson Modules

The "Fundamentals of Arc Stud Welding" consists of the following modules:

Module I - Initialization
Module 1 - About the Lesson
Module 2 - Theory
Module 3 - Studs and Ferrules
Module 4 - Welding Equipment
Module 5 - Welding Procedures
Module 6 - Inspections and Tests
Module 7 - Practice
Module 8 - Examination

These modules are arranged within the structure of the lesson such that all modules are administered to new trainees, while individual modules can be randomly accessed by experienced trainees who are receiving refresher or re-qualification training. Figure 2 illustrates the interaction of these modules.

Feedback

The form and timing of feedback to the trainee is the heart of interactive instruction. This feedback results from the trainee's response to a question or required action, and provides the immediate re-enforcemement so vital to the learning process. Many forms of feedback maybe used in an interactive lesson. Most authoring systems contain provisions for automatic feedback. Figure 3 illustrates some of the feedback loops used in the current project.

GETTING STARTED

Learning from interactive multimedia is an experience not to be missed. From the very start, its sights and sounds provide a continuous challenge, requiring the trainee to identify components by touching them to make simulated equipment adjustments and to answer questions.

The complete arc stud welding lesson covers theory, workstation set-up, operation of equipment, inspection of welds, and practice. Duration of the lesson depends upon the trainee. If all branches are viewed, the lesson will last approximately one hour. It is possible for a fast learner to take the entire lesson in less than half that time. This is one of the strengths of interactive instruction.

Upon being seated at the interactive workstation, a trainee begins by typing his or her name into the lesson management data base. This ensures that the trainee is approved for the course, and a file for

recording the trainee's progress is created. By touching the screen, the trainee is guided through a series of still and motion videos, animation, graphics, text, and narrations. Each module contains questions that must be answered. The lesson makes extensive use of simulation to describe procedures and encourage practice. Some questions require either a "point-to" or "button-Press" response from the trainee. The accuracy of these responses is used to determine whether the trainee should receive additional instruction; and, if so, what type of remediation it should be. If warranted the trainee receives a special remedial branch, or in some cases the original presentation is simply repeated. In all cases, the responses of the trainee are used to determine whether the lesson was completed satisfactorily. The end result is that the trainee becomes aware of his or her own capabilities, and management receives assurance that safe, cost-effective arc stud welding will be performed.

WHAT IS EXPERIENCED ALONG THE WAY

Fundamentals of Arc Stud Welding contains more than 200 "units," which is the authoring system's term for unique frames or screens. This means a slow learner has that many opportunities to receive

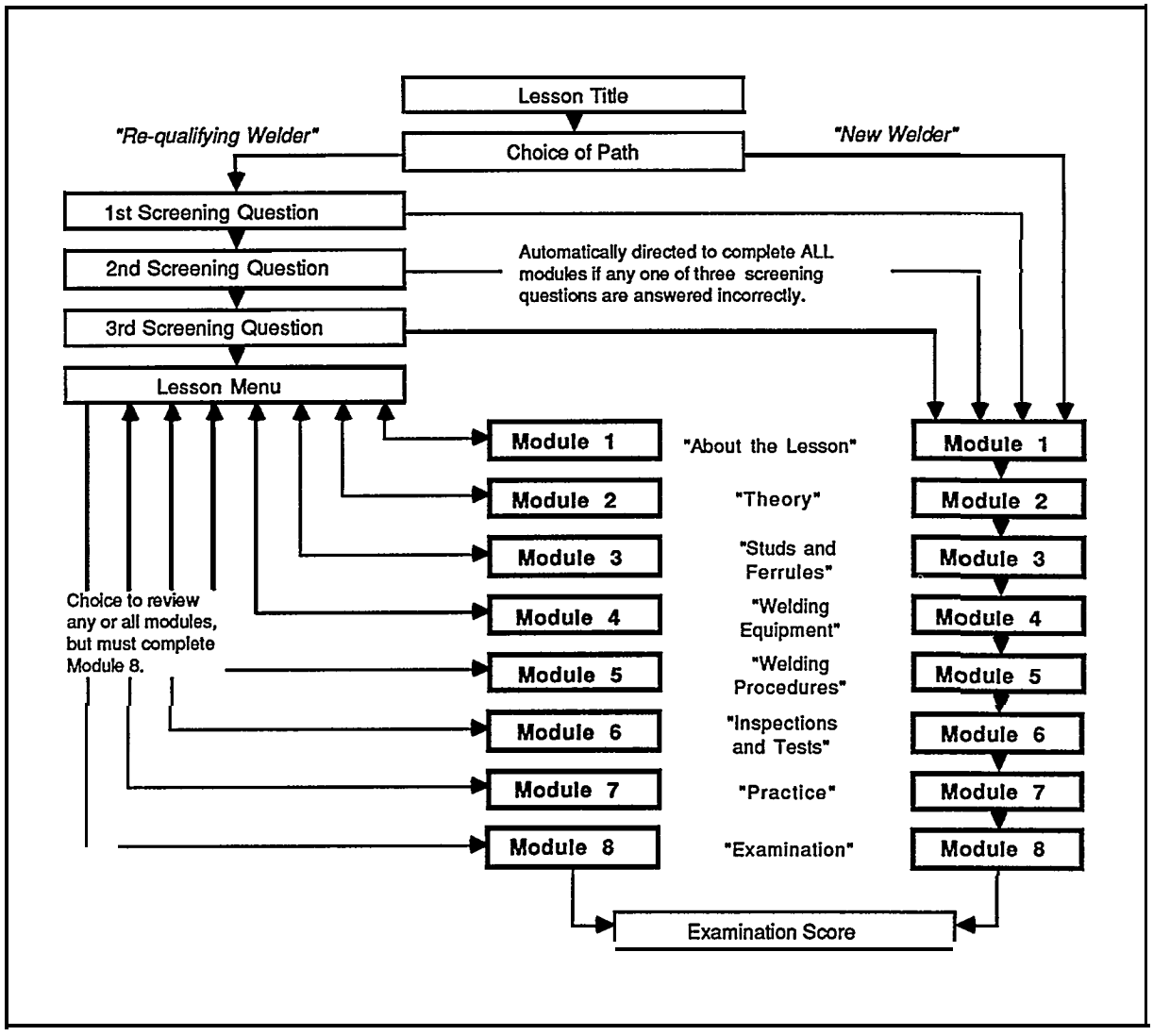

Figure 2 Modules of the Arc Stud Welding Lesson

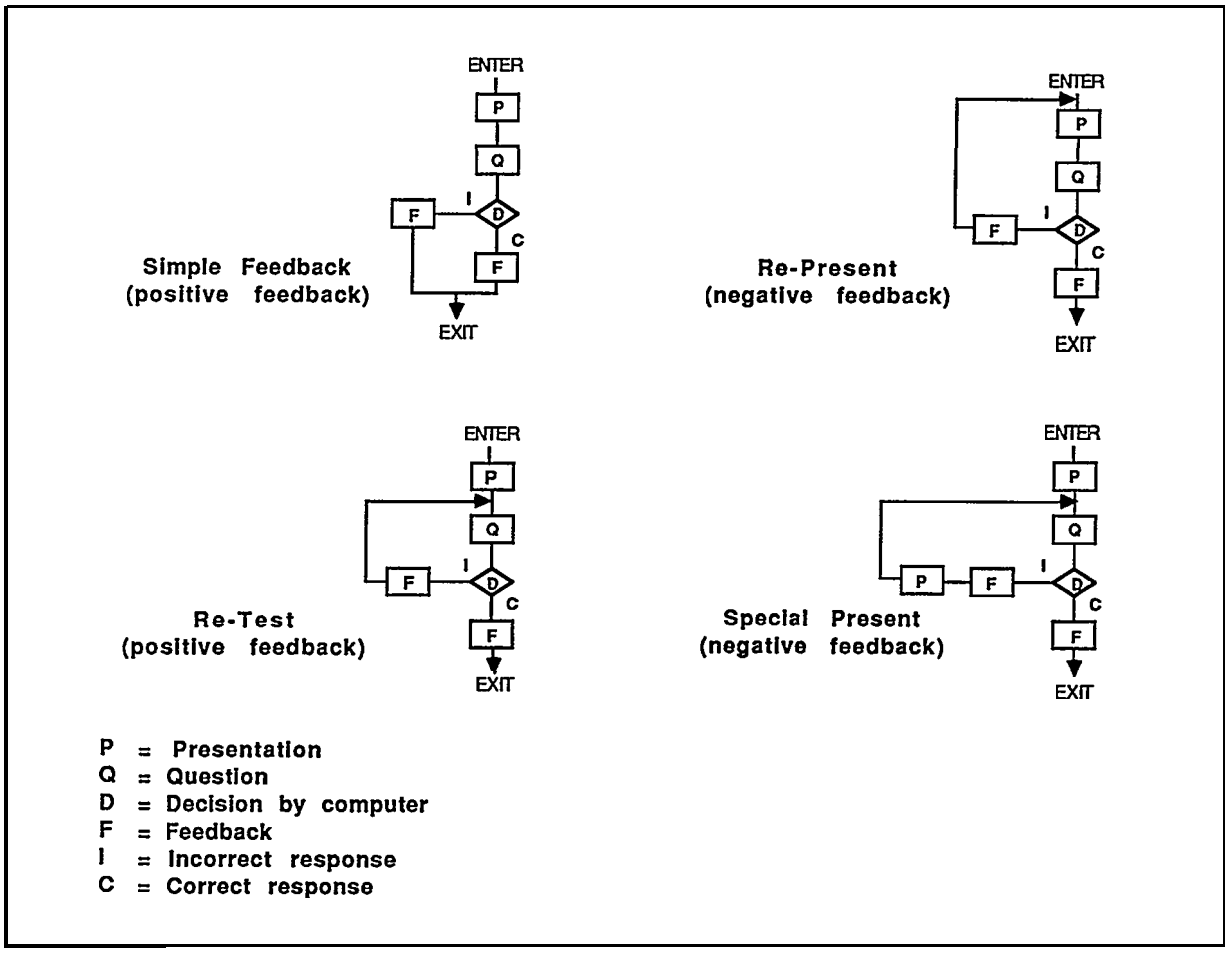

Figure 3 Examples of Inter-Module Feedback and Branching

information. The fastest learner will receive the same knowledge from significantly fewer units. The large number of units represents the opportunity to demonstrate many different instruction techniques, while making this objective of the project transparent to the trainee.

The lesson applies human factors engineering design criteria, which include simplicity of format, limiting the variety of color in text, attention to font and character size, maximizing the use of sound and motion, and avoiding unnecessary trainee interaction. The first module provides a brief description of how to operate the lesson. This knowledge is subtly expanded throughout the lesson so that the trainee can eventually perform relatively complex interactions.

A wide variety of feedback techniques are also demonstrated. Most authoring systems provide simple feedback capabilities within individual units, or the ability to branch to other units for more complex feedback. Feedback and branching are the basic ingredients of interactive instruction, and are well demonstrated by the project.

Interaction within a lesson is carried out predominantly by touching the screen. Trainees are asked to touch text panels, buttons, items in a picture or graphic, and, in some cases, "anywhere on the screen." It is accepted that the the touchscreen will be easier than a keyboard or mouse for stud welding trainees to use. There are, nevertheless, some interactions that require simple keyboard entries. These are included to demonstrate such interaction, and careful instructions are provided to guide the trainee in their use.

The presentation of information in the Fundamentals of Are Stud Welding lesson is intended to motivate and educate, while at the same time demonstrate flexibility in interactive screen design. A

variety of techniques for combining video and text are presented. Two unique opportunities for skill practice are provided through simulation. The first simulation presents the colored "flashes" of an electric arc along with its sound, and asks the trainee to identify the "best weld." While it can be argued that these cues are of limited value to a stud welder during actual practice, it does demonstrate how interactive multimedia can be used for sensory stimulation and basic perception tasks.

The second simulation presents pictures of welded studs with varying degrees of defects and nonconformity. The trainee is required to identify what adjustments should be made to the equipment to improve the weld, and then is shown, through a subsequent picture, the results of this adjustment. The simulation permits the trainee to make adjustments to the arc stud welding system, and to experience the consequences of this adjustment. This simulation is provided immediately before the final examination, and only after all other lesson material has been learned.

Motivation and verification are "built-in" to all aspects of the lesson. The trainee is constantly motivated through positive and negative feedback statements, both spoken and printed. Humor, a motivational technique applicable to some subjects, is limited. The lesson is structured to continuously challenge the trainee through the use of rewards and critiques. Both positive and negative feedback are included in the lesson.

FINISHING UP

At the end of the Fundamentals of Arc Stud Welding lesson the trainee is administered ten questions, each with only one correct response, that must be answered within a defined period of time. Although response time can also be used to test trainee reaction time, in this lesson the time element is used only to ensure that the lesson proceeds to the end. The method of trainee response is unique for each examination question. This enables the lesson to demonstrate ten different response techniques: specifically multiple-choice buttons, multiple-choice text, multiple-choice pictures, alternate-choice true/false or yes/no, pointing in a graphic, pointing in a picture, pointing in a video, numeric keyboard entry, text keyboard entry, and press-a-key. Questions are weighted differently in their contribution to the final score.

After the final question, all trainees are congratulated and invited to view their final score, which is derived from question criticality and other data. The instructor receives a full performance report, including a description of which questions were answered incorrectly.

TO DATE

To date, "Fundamentals of Arc Stud Welding" has been viewed only by project personnel involved in its development. The major test of this interactive lesson will come during the next year and beyond when shipyard management and training departments begin to use it, evaluate its benefits, and possibly develop some similar lessons on their own.

Results of the earlier NSRP report, “Recommendations on the Use of Interactive Instruction for Training Shipyard Trade Skills" (NSRP 0334/UMTRI 82210), revealed that while most American shipyards are not completely familiar with interactive instruction, most would be willing to participate in its demonstration. This interactive lesson provides that demonstration. It is intended that the lesson will enable American shipyards to better understand what interactive multimedia is, how the shipbuilding industry can benefit from it, and how interactive instruction can contribute to higher quality, cost-effective production in an ever-increasing competitive market.

REFERENCES

1. Fletcher, J.D., Effectiveness and Cost of Interactive Videodisc Instruction in Defense Training and Education, IDA Paper P-2372, Institute for Defense Analyses, Alexandria, VA. 1990.

2. Orlansky, J. and J. String, Cost Effectiveness of Computer-Based Instruction in Military Training, IDA Paper P-1375, Institute for Defense Analyses, Alexandria, VA. 1977.